3.0 RESULTS

3.1 Passage Through Spillbays

3.1.1 Recapture Probabilities

Recapture probabilities of treatment and control groups (both alive and dead physically retrieved) were high (>0.96) for the two experiments (Table 3-1). They ranged from 0.969 to 0.993 for the treatment groups and 0.961 for the control. The pooled recapture probability for the treatment group was 0.980. Chi-square analysis indicated that recapture probabilities of treatment fish between trials were homogenous within both treatment groups ($P>0.05$) but heterogenous among control trials ($P<0.05$). Much of the heterogeneity was due to trials 3, 6, and 7; each had 2 or 3 non-recaptured fish (exact status unknown or recovery of inflated tags without attached fish). However, because of many zero frequency cells, the chi-square test results may not be reliable (Appendix A).

The proportion of fish (treatment and controls) that were recaptured dead was negligible in all release groups (Table 3-1). The proportions of treatment fish that were physically retrieved dead were zero (0.0) in the flow deflector experiment, 0.007 in the non-flow deflector test, and zero (0.0) for controls. The proportions of treatment fish of unknown status or recoveries of inflated tags (without attached fish) were only 0.007 for the flow deflector test, 0.032 for the non-flow deflector test, and 0.039 for controls (Table 3-1). Most of these non-recovered fish (6 of 9) occurred in trials 1 and 2 of the non-flow deflector test, but were more randomly distributed for the control trials.

The likelihood ratio tests indicated that the recapture probabilities for alive (P_A) and dead (P_D) fish were equal ($P>0.05$) within each test scenario at 1 h and 48 h (Tables 3-2 and 3-3). Thus, for each test scenario the likelihood estimates ofS (probability of fish surviving from release point to recapture), (passage survival), or 1- (passage mortality), andP , with their associated standard errors (SE) were calculated using the simplified model (H_O:P_A=P_D). However, for the sake of completeness parameter values were also estimated under the generalized model (H_A:P_A *NE* P_D). The resulting parameter estimates and their associated standard errors are virtually identical for the two models (Tables 3-2 and 3-3).

3.1.2 Recapture Times

Recapture times (the time interval between release through the induction system until the fish was retrieved) for treatment and control groups were short and similar (Table 3-4 and Figure 3-1). Recapture times averaged less than 7 min for the two treatment groups. The difference in average recapture times of treatment and control fish was about 1 min and the variability (as indexed by standard deviations) was similar. Most fish were retrieved in less than 6 min (Figure 3-1). For the entire study, the average recapture time for the treatment groups was 6.5 min and 7.2 min for controls.

3.1.3 Survival Probabilities

The estimated immediate (1 h) survival probabilities were high and similar for both experiments (Table 3-5). The immediate (1 h) survival probability spillbay 2 was estimated at 1.0. Although the calculated survival probability was 1.0, 2 of 280 treatment fish (0.7%) were recaptured dead and had visible injuries (Table 3-1). The survival probability at spillbay 4 exceeded 1.0 (1.033) because a greater than expected proportion of control fish (11 of 280) either lost their tags or were not recovered (unknown). Because the survival probability cannot exceed 1.0, the immediate survival for spillbay 4 was also established at 1.0.

Little mortality of treatment fish in either test occurred over the 48 h period (Table 3-6). Only 2 of 278 (0.7%) treatment fish for the spillbay 4 experiment died, none of the treatment fish in the spillbay 2 experiment died. However, two control fish (2 of 267 or 0.07%) died. As a result, the calculated 48 h survival probabilities for a spillbay with and without a flow deflector remained at 1.0 (Table 3-5).

3.1.4 Injury Classification

For ease of understanding, injured fish were divided into two basic groups: fish with visible cuts and bruises (missing eyes, hemorrhaging, lacerations, etc.) and those with descaling or loss of equilibrium. Classification of descaling was consistent with the procedure used by the ACOE for smolt monitoring. A few fish with visible injuries also had major scale loss and/or loss of equilibrium. Each injured fish with a description of its injury is presented in Appendix B.

3.1.4.1 Type of Injuries

All the recaptured treatment (98.0%) and control (96.1%) fish released for the spillbay tests were examined for injury type and general location (Table 3-7 and Figures 3-2 through 3-4). Only 11 of 549 (2.0%) treatment fish were visibly injured while 2 of 269 (0.7%) of the controls were injured. Relative to controls, the injury rate attributable to spillage would be about 1.3% (2% minus 0.7%). Treatment fish incurred the following: injuries to the eyes (5), tear or split fin (4), bruise on head (1) and bruise on body (1). Eye injuries were characterized by hemorrhaging, bulging, and in one instance, the eye appeared to have burst (Figure 3-3). Some of the eye injuries diminished during the 48 h holding period. Two control specimens were injured; one was cut and abraded on the operculum while the other had a large tear below the dorsal tagging site (Figure 3-4).

The overall injury rate of fish passed through the spillbay with and without a flow deflector was similar (1.8 versus 2.2%) but the magnitude of specific injury type differed somewhat (Table 3-7). One fish passed by the flow deflector had eye injuries compared to four fish passed via the non-flow deflector; however, the small sample sizes of injured fish precluded determination of whether either route caused significantly different injuries.

3.1.4.2 Mortality Associated with Injury

Two of the five fish injured passing spillbay 4 (flow deflector) died over the 48 h period. Both of these fish had bruises; one to the body and the other to the head (Figure 3-2). One of the six injured spillway 2 treatment fish died immediately and as did another with 75% scale loss. The injured fish had eye damage and major scale loss (Figure 3-3). Both of the injured control fish died during the delayed assessment period.

3.1.4.3 Possible Cause of Injury

The observed scrape and bruise type injuries could have been caused by physically contacting features of the spillbay and tainter gate. Hemorrhaged and bulging eyes could have resulted from collision with solid objects. Bulging eyes have been attributed to pressure effects. However, the absence of other symptoms commonly indicative of pressure changes (expanded or burst air bladder, entrapped gas bubbles, etc.) suggested pressure change may not have been the cause (Cramer and Oligher 1964). Thus, the appearance of bulging eyes was likely mechanically inflicted. Although the dentates located below the Bonneville spillbays are small and deep (Figure 1-3) they may have contributed to some mechanical injuries. However, it is difficult to separate the specific effects of dentates from those due to large boulders or other hard objects that may be present there. Finally, the flow deflector design appears to inflict no additional harm to spilled salmon since the injury rate was similar for both spillbay types at Bonneville.

3.1.4.4 Descaling and Loss of Equilibrium

Besides the physical injuries discussed above two other effects on fish condition related to both testing procedures and spillbay passage were descaling and loss of equilibrium (Table 3-8 and Figure 3-4). Fish exhibiting only these symptoms, *i.e.*, absence of other injury types, are included herein. Fish were characterized as having lost equilibrium if they were not actively swimming when recaptured, or if their swimming was erratic.

The incidence of descaling was low for both spillbays (Table 3-8). Adjusting (percent treatment minus percent control fish) for controls the incidence of descaling ranged from 0 to 0.7% for the recaptured treatment fish. Incidence of lost equilibrium was also low. None of the fish passed through spillbay 4 displayed equilibrium loss while four passed via spillbay 2 were affected. Because one control fish was also affected, 1.1% of spillbay 2 passed fish were estimated to have been due to passage.

Little mortality appeared to be due solely to descaling and/or loss of equilibrium alone. Only one descaled fish was dead within an hour of passing spillbay 2 (Figure 3-4).

3.2 Passage Through Sluices

As indicated earlier, fish releases of limited scope were made at Bonneville Powerhouse 2 sluice (with the gate and without the gate) and the Powerhouse 1 sluice (Table 3-9). At Powerhouse 1 sluice fish were released at water surface. At Powerhouse sluice 2 fish were released about 2 ft below the water surface. Ambient water temperature was 14.0 and 15.0°C on the two days of sluice testing. Fish were similar in length to those released for the spillage test (mean 118.6 to 128.3 mm total length).

A total of 100 fish were released through the Powerhouse 1 sluice (Table 3-9); 93 fish were recaptured alive and all were alive at 48 h. Nothing was recovered for 6 of the fish and one inflated tag recovery occurred. The average recapture time was about 5 min.

At the Powerhouse 2 sluice test, two separate releases were made (Table 3-9). One release consisted of 30 fish when the gate at the end of the sluice was in place and the second release was comprised of 70 fish without the gate (Table 3-9). The primary reason for separate fish releases was that during the initial release of 30 fish, the average recapture time was longer and variable than expected (11.2 min, standard deviation 13.3 min) and recapture probability lower than experienced elsewhere recently (20 of 30 fish or 0.67). The exact status of seven fish could not be determined, three fish exhibited tag dislodgement. One of the 20 fish held for 48 h died. Several weeks later balloon tags from 4 of the 7 fish of unknown status were found by station personnel at a screened area of the auxiliary water supply system for the adult fishway (personal communication, Jim Kuskie, Fisheries Biologist, Bonneville Dam). Upon site investigation, it appeared that the presence of the gate caused some fish to be diverted into a side channel with the flow. Therefore, a second set of fish releases was made without the gate. Mean recapture time dropped to 6.2 min, consistent with other studies (Tables 1-1 and 1-2).

For the Powerhouse 2 sluice test without the gate, all 70 (100%) of the fish released were recaptured alive and remained alive through 48 h (Table 3-9).

3.2.1 Injuries, Scale Loss, and Loss of Equilibrium

Although only 100 fish were passed through each sluiceway at the two powerhouses, the condition of the recaptured specimens indicated both routes were relatively benign at the conditions tested. Only 1 of 90 and 1 of 93 of the fish recaptured from Powerhouse 2 and 1, respectively, had any visible injuries (Table 3-10). Both specimens had an injured eye (hemorrhaged, bulging). Scale loss and loss of equilibrium was also low (Table 3-10). One fish that passed the Powerhouse 2 sluice was disoriented when recaptured and one fish from the Powerhouse 1 sluice test was descaled. None of the fish recaptured from Powerhouse 1 died but the disoriented fish from Powerhouse 2 sluice died.

3.2.2 Identification of Potential Passage Problems at Sluices

The tag-recapture technique identified a potential juvenile fish passage problem at the Powerhouse 2 sluice. The installation of the end bulkhead raises the water level of the flume by about 10 ft causing diversion of a portion of the flow into a side channel with a screened area that supplies auxilary water to the adult fishway. This partial flow diversion carried some fish into the side channel. Although the bulkhead at the end of the sluice increases water depth, and possibly reduces the probability of plunging fish striking the concrete bottom of the sluice it may also divert emigrants into a "dead end" area. It may prove beneficial to monitor fish passage into this side channel or block it should the Powerhouse 2 sluice be used to bypass juvenile salmon with the end gate in place.

Another problem associated with sluice passage at Powerhouse 1, though non-quantifiable at present, is the likelihood of increased predation at the sluice outfall. Based on radiotelemetric monitoring four fish were presumed preyed upon; however, it was unknown whether predation occurred on alive, dead, or injured fish. This is in contrast to the absence of apparent predation on fish passed through the Powerhouse 2 sluice (0 of 100 fish) and only 3 of 840 released at the spillbays. Chi-square analysis revealed significant differences ($P>0.01$) between those frequencies. These observations suggest that the Powerhouse 1 sluice outfall area may warrant further monitoring for predation potential